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IS 1528-19 (1991): Methods of Sampling and Physical Tests for Refractory Materials, Part 19: Determination of thermal expansion [MTD 15: Refractories]



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Indian Standard

**METHODS OF SAMPLING AND PHYSICAL
TESTS FOR REFRACTORY MATERIALS**

PART 19 DETERMINATION OF THERMAL EXPANSION

UDC 666.76 : 620.113

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FOREWORD

This Indian Standard (Part 19) was adopted by the Bureau of Indian Standards, after the draft finalized by the Refractories Sectional Committee had been approved by the Metallurgical Engineering Division Council.

Determination of thermal expansion (reversible thermal expansion) was given as an appendix to IS 4812 : 1972 'Specification for silica refractories for coke oven'. The technical committee felt that it will be appropriate if a separate standard is published as a part of series of Indian Standards on methods of sampling and physical tests for refractory materials.

Assistance has been taken from BS 1902 : Part 1A : 1966 'Methods of testing refractory materials — Sampling and physical tests' in the formulation of this standard.

For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the result of a test or analysis, shall be rounded off in accordance with IS 2 : 1960 'Rules for rounding off numerical values (*revised*)'. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

Indian Standard

METHODS OF SAMPLING AND PHYSICAL TESTS FOR REFRACTORY MATERIALS

PART 19 DETERMINATION OF THERMAL EXPANSION

1 SCOPE

1.1 This standard prescribes the methods of test for determination of thermal expansion. The standard covers two methods:

- a) Dial gauge method for temperatures up to 1 150°C

NOTE — This method is suitable for occasional measurements up to 1 200°C. Repeated heating to 1 200°C may produce some decitrification of the fused silica tube and change its expansion characteristics. It is recommended that an apparatus which is frequently used for tests up to 1 200°C should be recalibrated regularly for example after every 10 tests.

- b) Electrical method for temperature between 1 150°C and 1 500°C.

2 REFERENCES

2.1 The following Indian Standards are necessary adjuncts to this standard.

IS No.	Title
1528 (Part 7) : 1974	Methods of sampling and physical tests for refractory materials: Part 7 Methods of sampling and criteria for conformity
4041 : 1987	Glossary of terms relating to refractory materials

3 TERMINOLOGY

3.1 For the purpose of this standard, the definitions given in IS 4041 : 1987 shall apply.

4 DETERMINATION OF THERMAL EXPANSION BY DIAL GAUGE METHOD FOR TEMPERATURE UP TO 1 150°C

4.1 Apparatus

4.1.1 Horizontal Type

The apparatus to be used is illustrated in Fig. 1. It is mounted on a slate base (*W*). The fused silica tube (*AB*) is closed at the end (*A*) by a ground and polished disk of fused silica, the other

end (*B*) being fixed to the stand (*T*). At point (*D*) in the tube, corresponding to the mid-point of the furnace (*F*) tube and of the test piece, two holes pierce the top of the tube and through these are threaded the two wires of a platinum 'v' platinum rhodium thermocouple.

The test piece (not shown) lies in the tube between the end (*A*) and the end of the fused silica rod (*XY*). This rod just fits in the silica tube (*AB*) and can move longitudinally without touching the walls, since it is supported from the end (*Y*), which is compensated into a hole in the iron/36 percent nickel alloy rod (*Z*). The pulleys *P*₁ and *P*₂ (which are mounted on ball bearings) carry the iron/36 percent nickel alloy rod (*Z*), which is free to move backwards and forwards with minimum resistance.

The iron/36 percent nickel alloy rod transmits the movement of the end of the test piece to a micrometer dial gauge (*G*) which is bolted in a slot in the mounting bracket (*S*). The micrometer dial gauge is graduated in divisions of 0.01 mm.

4.1.2 Vertical Type

The apparatus to be used is illustrated in Fig. 2. It consists of a cylindrical electric furnace of 500 W capacity placed vertically, a fused silica tube closed at one end and centrally suspended within the furnace from top, and a fused silica rod for transmitting the expansion or contraction of the sample. A direct dial gauge of 1.0 cm range with the finest graduation of 0.01 mm is used for measuring the linear change of the specimen. The furnace top is covered with a metallic plate having a central grooved seat for metallic flange fitted to the open end of the fused silica tube. This arrangement helps in keeping the tube exactly vertical as well as in the centre of the furnace. The block to the dial gauge which accurately fits in the flange on the tube. All these metallic parts are cooled by running water during the test. Thermocouple is inserted in the tube so that the hot junction touches the middle of the test specimen.

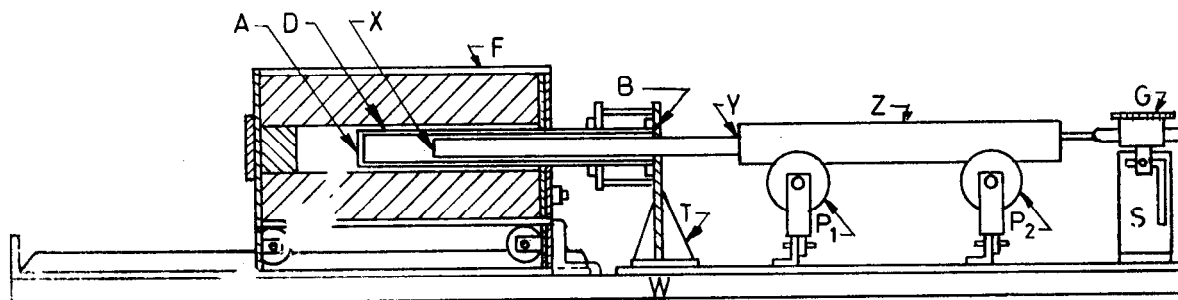


FIG. 1 HORIZONTAL TYPE THERMAL EXPANSION APPARATUS

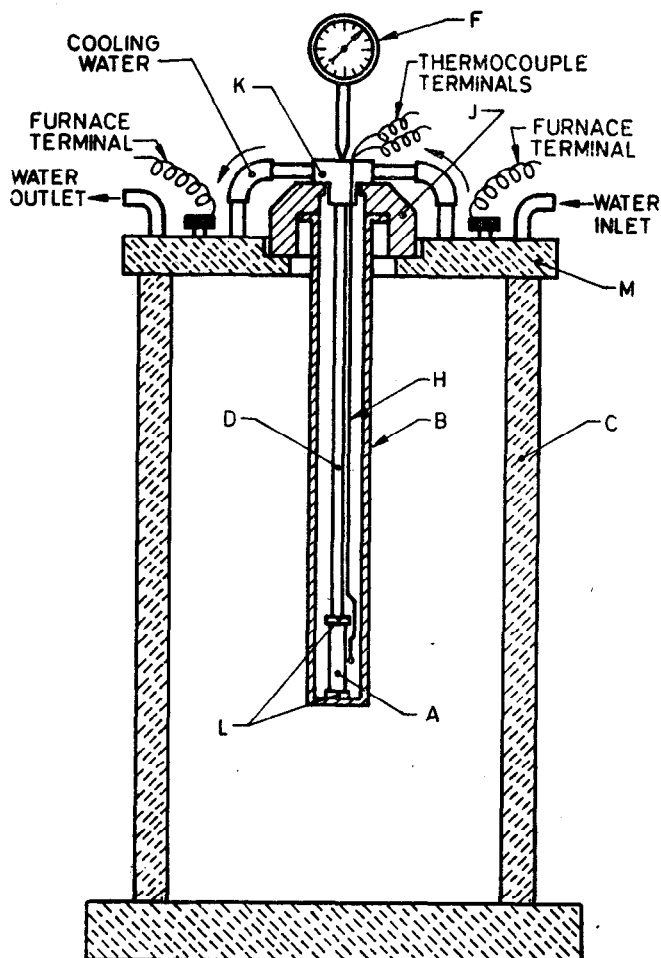


FIG. 2 DIAL GAUGE APPARATUS FOR THE DETERMINATION OF REVERSIBLE THERMAL EXPANSION

4.2 Calibration

To allow for any temperature variation between the outside silica tube and the specimen and for the expansion of the length of fused silica tube surrounding the silica tube the apparatus shall first be calibrated. With a 50 mm test piece of fused silica, a calibration test shall be carried out at the standard rate of heating to 1 000°C and any deviation from the zero reading on the dial gauge shall be noted. The expansion figures obtained in all subsequent tests with the apparatus shall be corrected by addition of the difference between the dial reading at a given temperature during the calibration test and the true expansion of 50 mm test piece of fused silica at that temperature.

4.3 Test Specimen

The test specimen shall be 50 mm in length and 10 mm in diameter and shall be obtained from the sample either by core drilling, or by cutting and grinding.

4.4 Test Procedure

Measure the length of the test specimen accurately by slide callipers. Place the test specimen inside

the fused silica tube in between the two fused silica discs so that the specimen is not displaced during the test. Place the fused silica rod on the upper fused silica disc on top of this specimen. Introduce a suitable (for example, platinum/platinum-10 percent rhodium), thermocouple within the tube so that its hot junction is almost at the centre of the specimen. Place carefully the metallic block into the metallic flange on the fused silica tube so that its hot junction is almost at the centre of the specimen, tube, discs, rod, etc, is absolutely free in movement. Put this assembly on the cover plate of the furnace and set the dial gauge under slight compression on the metallic block for recording the expansion or contraction. Start heating the furnace and control the rate of heating at 3 to 4°C per minute. The thermocouple shall be connected to a temperature recording device. The temperature along with the reading of the dial gauge shall be noted every 5 minutes.

4.5 Report of the Results

The dial gauge reading at 1 000°C corrected according to calibration data gives linear change for the sample and shall be expressed as percentage of the original length of the specimen. If necessary a graph relating to expansion and temperature may also be plotted.

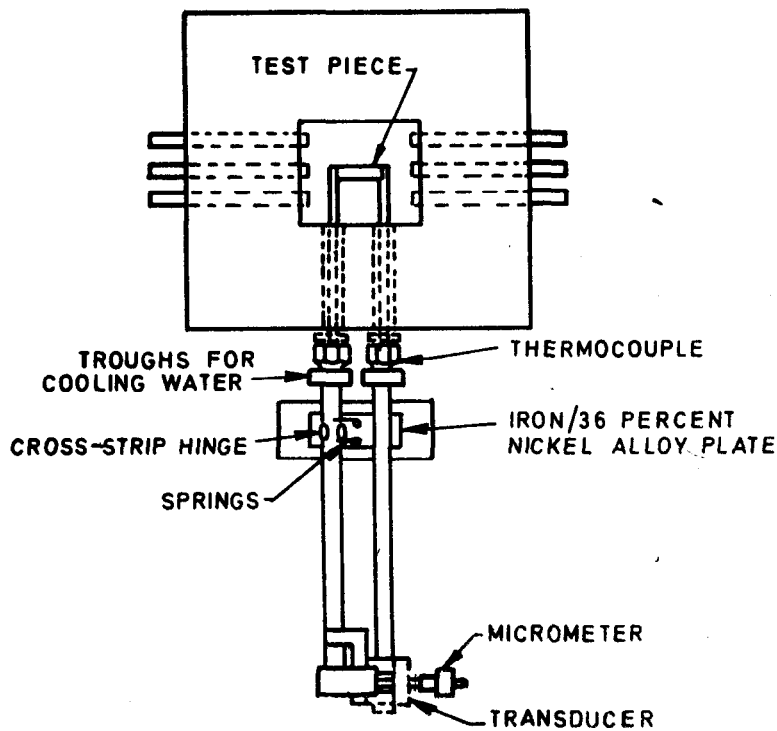
5 DETERMINATION OF THERMAL EXPANSION BY ELECTRICAL METHOD FOR TEMPERATURES UP TO 1150°C AND 1500°C

5.1 Apparatus

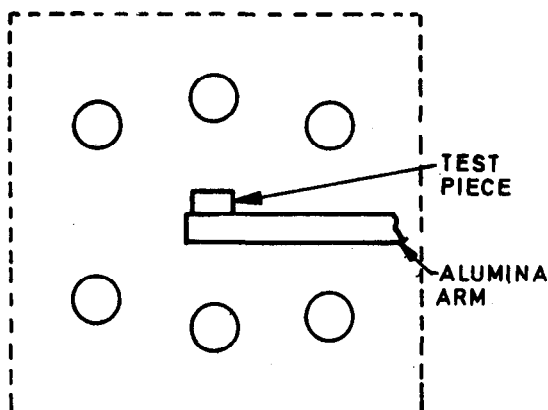
5.1.1 It consists of suitable furnace with a heating chamber 125 mm by 100 mm fitted with a removable lid and heated by six heating rods 11 mm in diameter arranged around the test piece as shown in Fig. 3A and 3B. Two holes (approx 12 mm in diameter) are drilled through one wall of the furnace to accommodate the specimen carrier arms.

These arm are 50 cm long one is fixed and the other pivoted at its mid point by a crossed strip

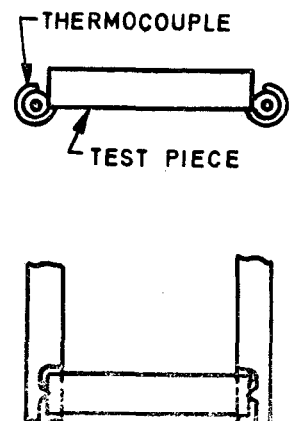
hinge. The fixed arm and the hinge are mounted 5 cm apart on an iron/36 percent nickel alloy plate which is held on columns fixed to a suitable levelling table. The parts of the arms projecting into the furnace consist of recrystallized alumina tube 8 mm external diameter 5 mm internal diameter and 20 mm long, the remaining parts being steel. A quadrant is cut from the end of each tube to form jaws to hold the specimen and the upper cut edge is ground to leave a small projection, as shown (Fig. 3C). The pivoted arm is lightly sprung towards the specimen (a force of 1-2 g at the end of the arm is suitable). Small radiation shielded are fitted to the arms and water cooling is applied to the inner end of the metal arms. The fixed arm carries a thermocouple which is passed down the alumina tube and rests against one end of the specimen.



3A Plan of Apparatus



3B Arrangement of Heaters



3C Position of Test Piece in Alumina Jaws

FIG. 3 THERMAL EXPANSION APPARATUS (ELECTRICAL MEASUREMENT)

The specimen is held between the ends of two horizontal arms, one of which is fixed and the other pivoted at its mid-point when the specimen expands the other end of the arms are closed together by a similar distance.

A linear transducer is mounted on the ends of the arms opposite to the test piece. The transducer shall have the following characteristics:

- a) Stable over the required period under the conditions of the test.
- b) Able to detect a movement of 0.000 2 cm.
- c) Exert no detectable constraint on the moving arm.
- d) Give a final d. c. voltage, proportional to the movement of the arm, which can be indicated or recorded on a transducer.

5.2 Test Specimen

The test piece shall be cut or ground and shall be either a prism 5 cm long and 1 cm square or a cylinder 5 cm long and 1 cm in diameter. The two ends shall be flat and parallel to each other.

5.3 Test Procedure

The length of the test piece shall be accurately measured and it shall then be inserted through

the top of the furnace into the jaws so that the small projection on each jaw is on the vertical centre line of each end face of the specimen. The furnace lid is replaced and the calibration of the transducer checked by means of a micrometer which is permanently attached thereto (see Fig. 2). The test piece shall be heated at a steady rate between 5°C/min and 10°C/min and the readings of the temperature and the change in length of the test piece, as shown by the transducer, are recorded at 5 minute intervals or as required. The expansions of the alumina arms, which is at right angles to the direction of measurement of the specimen, will have a negligible effect on the result.

5.4 Report of Result

The measured expansion shall be calculated as percentage of the original length of the specimen. If necessary, a graph relating to expansion and temperature may also be plotted.

6 SAMPLING AND CRITERIA FOR CONFORMITY

6.1 The procedure for sampling and the criteria for conformity shall be as laid down in IS 1528 (Part 7) : 1974.

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